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L. O. HOWARD, Chief.

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CHRYSANTHEMUM MIDGE.[1]

By C. A. WEIGEL and H. L. SANFORD, *Collaborators, Tropical and Subtropical Fruit Insect Investigations.*

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GENERAL DESCRIPTION.

The chrysanthemum midge, *Diarthronomyia hypogaea* (F. Löw), is a European insect which gained entrance into the United States a few years ago and since then has been reported as injurious from widely separated localities in this country and Canada.

When chrysanthemums are infested by this midge, the attention of the casual observer is most likely to be drawn to the presence of galls. These galls occur on the leaf, stem, or flower head of the chrysanthemum plant. (See Pl. I, B and C.) After the larvæ hatch from the orange-colored eggs, which are deposited by the adult female on the surface of tender tips and new growth, they bore their way into the tissues, thereby giving rise to the galls.

The galls are cone-shaped and generally project obliquely from the surface. The length of the gall when fully developed is about one-

[1] The account of the chrysanthemum midge contained in this bulletin is the result of an investigation which was undertaken with the intention of providing further data on the life history and habits of this insect, as well as more satisfactory means of control. The preliminary life-history studies which were started in February, 1917, by A. D. Borden, of the Bureau of Entomology, were subsequently taken up by H. F. Dietz, of the Federal Horticultural Board. Further studies on life history and control were inaugurated and carried to completion by the writers as a result of the many inquiries for advice as well as the outbreaks reported during the chrysanthemum season of 1918 and the spring of 1919. During the entire period the work has been under the constant supervision of E. R. Sasscer, chief inspector of the Federal Horticultural Board and collaborator of the Bureau of Entomology.

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twelfth of an inch. When the leaf is affected, the galls usually occur on the upper surface. In such cases a slight swelling often may be observed on the opposite or under side of the leaf. Growth and development of both larva and pupa take place within this gall. When the pupa is fully developed it pushes itself out of the gall, still inclosed in the pupal skin. The latter then splits down the middle of the head and back to allow the adult to emerge. (See Pl. II, C.)

In the adult stage the midge is a fragile two-winged fly, one-fourteenth inch in length. The abdomen of the male is yellowish orange, while that of the female is reddish orange. The adult on emerging leaves its pupal skin protruding from the opening of the empty gall. (See Pl. II, A.) As shown in the life-history studies, the adults emerge after midnight and egg-laying takes place early in the morning.

HISTORICAL.

In 1870, E. Perris (1, p. 177)[1] is recorded as having observed cecidomyiid larvæ on *Leucanthemum vulgare*. Six years later J. E. Von Bergenstamm and P. Löw (2) also recorded larvæ which in all probability were cecidomyiid, as they were found attacking the young leaves of *Chrysanthemum leucanthemum* (*Leucanthemum vulgare*.) In August, 1875, E. Berroyer collected specimens in Raxalpa, a group of the Eastern Alps of Austria-Hungary, at an elevation of 5,000 feet above sea level. These specimens, which consisted of subterranean galls, and two adult male midges, were submitted to Franz Löw (3) by Von Bergenstamm. Franz Löw made the original description in 1885, which freely translated is as follows:

Male: Antennæ 2–14 jointed. Peduncle shorter than the segments. Terminal segment with two whorls of stout setæ. Wings cloudy white. All veins, also costal vein white. Second parallel vein straight, disappearing in the apex of the wings. First branch of the third parallel vein so weak that it is not visible, unless under best of light and high power, but the wing fold on the other hand is very plainly discernible. Halteres white. Legs with closely adhering hairs, also appearing white.

Larva: The still unknown larva causes galls on the underground parts of the stem of *Chrysanthemum atratum* Jacq., in which their complete transformation takes place. In each are also found several larvæ, each larva occupying one cell for itself.

Pupa: The pupa has (like the pupa of the Asphondylia species) three pairs of horns, but on the other hand, lacks the rows of delicate horns found on the dorsal surface of abdominal segments of the Asphondylia species.

The two cephalic horns are very large, widely separated, slender, quite pointed and with the point somewhat recurved. The horns of both other pairs are very small, alike in size and structure, pointed and also with the point somewhat recurved. They occur in such a manner that a horn is located above and below each eye of the pupa; consequently, the horns of one pair are widely separated from each other. In the cells of the galls in which pupation of the larva takes place, the pupæ are so situated that the head points to the periphery of the gall.

[1] Numbers in parentheses refer to "Literature cited," p. 23.

Galls: They occur, three or four in number, at the extremity of the upper and lower surfaces of the stem of the *Chrysanthemum atratum* Jacq., which is irregularly rounded, varying in size from a large hemp seed to a large pea. Outside naked, consisting of a fleshy homogeneous mass in which occur small, elongated cells or chambers each being inhabited by a larva.

Distribution: On Raxalpa about 5,000 feet above sea level. (E. Berroyer.)

From this date, until it was first reported by Felt in the United States, frequent references are found in literature relating to its occurrence and synonymy. Among these may be listed the following: Rübsaamen (4, p. 375), Kieffer (5, p. 21), (6), (7, p. 351, 353), (13), Baldrati (8, p. 40–41), Kertész (9, p. 69), Houard (11), and Küster (12, p. 77, 274).

On March 26, 1915, R. H. Pettit of the Michigan Agricultural College had his attention called to the existence of an infestation occurring in large chrysanthemum houses at Adrian, Mich. Specimens were submitted to E. P. Felt (14), State entomologist of New York, who in April of that year determined it as the chrysanthemum midge, *Diarthronomyia hypogaea* (F. Löw). In 1916 A. Gibson (21) reported the occurrence of the midge at Ottawa, Canada. Subsequently, reports of its occurrence have been received from widely separated points, both in the United States and Canada. According to California florists, this pest has been present in that State for about 15 years.

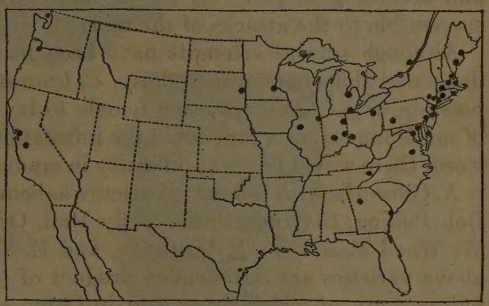


FIG. 1.—Map showing distribution of the chrysanthemum midge in the United States and Canada.

DISTRIBUTION IN THE UNITED STATES AND CANADA.

To date, the midge has been reported from California, Connecticut, Delaware, the District of Columbia, Georgia, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, and Virginia, as well as from Ottawa and Victoria, in Canada.

Since the first records of its occurrence and seriousness were reported from the Middle West it would appear that the distribution of infested plants from this region was the source of its further spread to the other sections of the United States and Canada.

Its distribution, as indicated on the accompanying map (fig. 1), is almost wholly confined to the larger chrysanthemum-growing regions of the United States, which include the areas surrounding the Great

Lakes and the northern and central Atlantic seaboard. On the Pacific coast it is reported from California and Oregon, and its presence has been confirmed in South Dakota, Tennessee, and Georgia. Doubtless a careful survey would locate many additional isolated infestations which have not been brought to the attention of State or Federal entomologists.

VARIETIES AFFECTED.

While the chrysanthemum midge has been recorded from central and southern Europe as seriously injuring the common white or ox-eye daisy (*Chrysanthemum leucanthemum*), as well as *C. corymbosum*, *C. atratum*, *C. japonicum*, and *C. myconis* (11), its depredations in North America are confined to practically all of the commercial chrysanthemums, both the single and pompon varieties. The first infestation in this country was reported on the variety Mistletoe, and according to Felt (14, 15, 16) this variety appears to be very susceptible to the attacks of the midge.

Although several attempts have been made to infest the Shasta daisy and the common field daisy, *C. leucanthemum*, it has not been possible to get the ovipositing female to lay eggs on them. This is of much importance, for should the infestation spread to this common weed, there would be great difficulty in eradicating this pest.

A. Gibson lists the following varieties as being fairly free from injury: Bob Pulling, Gertrude Peers, Daily Mail, Oconta, Mrs. G. C. Kelly, W. Wood Mason, F. T. Quilleton, and E. T. Quittington. All the above varieties are the blended product of *C. indicum* and *C. morifolium*, both of which grow wild in China and Japan. He reports the following varieties as being practically ruined: Smith's Advance, Ivory, Bonnaffon, Wm. Turner, Western King, and Englehart.

Observations made by H. F. Dietz in the Middle West showed that the Wm. Turner variety had lost all the crown buds. In case of a thick infestation on the variety Dr. Enguehard all of the plants had to be discarded early in the season; also all Chadwick varieties, as well as Elberon, Major Bonnaffon, and Golden Mensa. The varieties which seemed to be least injured were Golden Age, Harvard, and White Bonnaffon.

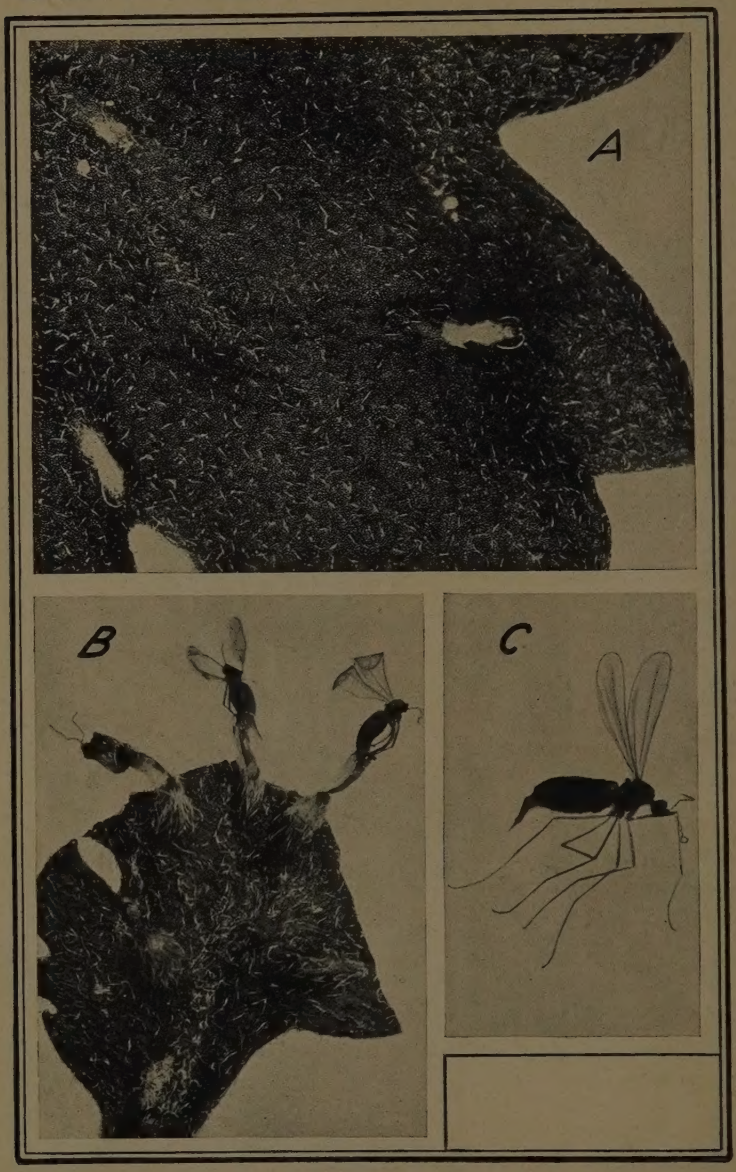
In some of the greenhouses of the District of Columbia during the season of 1918-1919 such varieties as Mensa, William Turner, and the white and yellow Bonnaffon were completely ruined on account of the severe infestation.

ECONOMIC IMPORTANCE.

Although a comparatively recent introduction this insect now seems to be firmly established in the United States and is one of the most important pests to be reckoned with by chrysanthemum growers.

THE CHRYSANTHEMUM MIDGE.

A, Adults emerging. *B*, galls of midge on chrysanthemum leaf. *C*, injury to terminal growth. *D*, adult emerging from stem gall.



THE CHRYSANTHEMUM MIDGE.

A, Empty pupal skins protruding from galls after emergence of adults. *B*, adults killed while emerging as a result of being sprayed with nicotine sulphate. *C*, adult female midge.

While it is primarily a greenhouse pest, A. Gibson, in August, 1915, found it occurring on both greenhouse and outdoor plants at Ottawa, Canada. Well-developed galls on the newly unfolded leaves were found by the authors, March 26, 1919, on hardy chrysanthemums which had been grown out of doors all winter at the Arlington Farm, Rosslyn, Va. A careful inspection of the entire stock revealed the fact that the insects had wintered over on these plants in the immature stages, probably as either larvæ or pupæ within the galls. Inasmuch as there were many empty galls present on the old dead and dried leaves of the previous season's growth, it was evident that this was an infestation of long standing. On April 11, many adults were found entangled in webbing spun by spiders among the developing new tip growth. These emerged from the above mentioned galls.

The first severe infestation of the midge brought to the attention of the Bureau of Entomology was on chrysanthemums in greenhouses at Philadelphia, April, 1917. The entire stock was infested, causing a total loss to the grower. During the same year other florists reported a total loss of their stock of chrysanthemums valued at several thousand dollars. Even in the case of a light infestation the foliage is practically valueless for commercial purposes, and in the case of a heavy infestation the growth is completely arrested. (See Pl. I, C.)

Owing to numerous reports of injury by the chrysanthemum midge in the States of Indiana, Illinois, and Michigan, H. F. Dietz conducted a survey in this territory during the months of November and December, 1918, for the purpose of ascertaining the exact amount of damage occasioned by this pest. From the data gathered, this general locality proved to be one of the centers from which the pest was being distributed over the United States. Greenhouses of 33 florists were visited, including some of the largest growers and distributors in this country. It was evident that if serious pests were established in this region, it would be only a matter of a year or two before such insects would be widely scattered. This is exactly what has happened in the case of the chrysanthemum midge. This pest was found established in 8 of 33 places visited.

Serious injury to infested plants was noted. For example, no plants of the variety Dr. Enguehard came into flower, on account of their dwarfed, knotted, and knarled condition, with the result that the new central stem did not form. Moreover, other varieties, including Wm. Turner, were attacked just at the time the crown buds were "setting," causing these flowers to become distorted. As a result, the flowers are not borne upright as normal flowers should be. Such evidence may be taken as an indication of the presence of the midge, even though the galls may not be numerous enough to attract attention.

From these data it is apparent that the insect is a serious pest, especially in cases where growers require from 50,000 to 100,000 plants for their own use and five to ten times this number to fill annual orders for shipment.

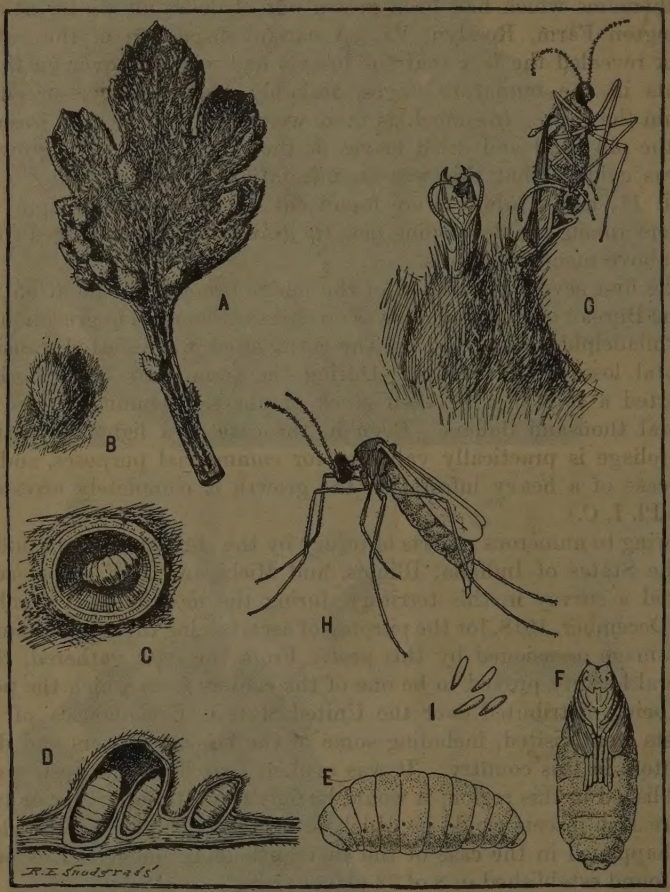


FIG. 2.—The chrysanthemum midge: *A*, Leaf covered with galls; *B*, a single gall, more enlarged; *C*, gall cut open from above, showing young larva within; *D*, two galls cut in vertical section; *E*, larva, enlarged about 13 times; *F*, pupa; *G*, fly emerging from a gall on right, discarded pupal skin remaining in opening of gall on left; *H*, adult female fly, enlarged about 13 times; *I*, eggs. (9th Ann. Rept. State Ent. Ind.)

TECHNICAL DESCRIPTION.[1]

Egg [fig. 2, I].—Reddish orange, length .15 mm., diameter .03 mm., the extremities narrowly rounded.

Gall [fig. 2, A, B, C, D, G].—Conical swelling projecting obliquely from the surface. Size about 2 mm. in length. Color, generally green. Reddish green when growing outside and depending on variety affected. Tips appear dried out and grayish at

[1] Technical description of egg, larva, pupa, male, and female taken from Felt (20).

times. Hairs on tip in superabundance. Occurring on both leaf surfaces, stem and flower head.

Larva [fig. 2, C, E].—Length 1 mm., yellowish or yellowish orange when full grown, moderately stout, the extremities rounded; segmentation distinct and the skin smooth.

Pupa [fig. 2, F].—Length 1.25 mm., stout, narrowly oval, the cephalic horns distinct, conical, the thorax yellowish orange, the wing pads fuscous in pupæ nearly ready to transform, the leg cases dark yellowish brown, the abdomen a variable orange, narrowly rounded apically.

Male.—Length 1.75 mm. Antennæ nearly as long as the body, sparsely haired, fuscous yellowish; 17 or 18 segments, the fifth with a stem about three-fourths the length of the subcylindric basal enlargement, which latter has a length about twice its diameter and a rather thick subbasal whorl of long, stout setae; terminal segment variable, usually somewhat reduced, irregular, elongate, ovate. Palpi: The first segment subquadrate, the second narrowly oval. Mesonotum dark brown, the submedian lines yellowish. Scutellum and postscutellum fuscous yellowish, the abdomen mostly a pale yellowish orange. Wings hyaline, costa light straw, halteres yellowish transparent. Legs a pale straw, the pulvilli a little longer than the long, slender claws, the latter with a long, slender tooth basally. Genitalia; basal clasp segment moderately long, stout; terminal clasp segment short, stout, with a distinct spur; dorsal plate short deeply and roundly emarginate, the lobes short, broad, obliquely truncate apically; ventral plate short, deeply and roundly emarginate, the lobes rather long and tapering to a narrowly rounded apex.

Female [fig. 2, H].—Length 1.75 mm. Antennæ extending to the third abdominal segment, sparsely haired, fuscous yellowish; 16 or 17 segments, the fifth with a stem about one-third the length of the cylindric basal enlargement, which latter has a length a little over twice its diameter; terminal segment reduced, sometimes compound and tapering to a narrowly rounded apex. Palpi: The first segment subquadrate, the second subconical and with a length a little greater than the first. Mesonotum fuscous brown, the submedian lines, the posterior median area, the scutellum and postscutellum mostly fuscous yellowish, the apex of the scutellum narrowly fuscous. Abdomen reddish orange, apically fuscous yellowish, the ovipositor about one-half the length of the body; terminal lobes short, broad, broadly rounded and sparsely setose apically. Other characters practically as in the male.

LIFE HISTORY AND HABITS.

ADULT STAGE.

The adult female shows a marked preference to lay eggs in the buds, or in the tissues just unfolding from the buds. Serious injury to the host results from this habit, and the commercial value of the plant is greatly reduced, if not entirely eliminated.

Emergence of adult.—On March 26, 1919, H. L. Sanford observed the emergence of a female at 1.09 a. m. On the following night observations by C. A. Weigel taken at intervals varying from 15 to 20 minutes apart beginning at 12.30 a. m., and ending at 5.45 a. m., showed the emergences as follows: At 1 a. m., 1 female; at 4 a. m., 1 male; at 4.02 a. m., 4 females, 3 males. In addition the following observations were recorded: When the female emerges the body is pushed out of the gall for approximately three-fourths its length. The wings at this time appear as dark gray or black club-like appendages. The antennæ are moved about in a very active manner. The legs, which are at first folded parallel to the body, are thrust outward

and immediately begin movement. The body is swayed back and forth with contractions of the abdomen which is still inserted within the gall, the latter acting as a fulcrum. In about two minutes from the time at which the adult is first seen to break through the gall, the entire body is freed from its pupal skin. The pupal skin remains protruding from the empty gall case, as seen in Plate II, A. With a convulsive motion the insect gains a foothold by thrusting out the legs and was observed almost immediately to travel rapidly to the underside of the leaf, assuming a position at right angles to the leaf surface. In this hanging position, which is characteristic of the adult female, it remained over an hour, occasionally fluttering its wings. Upon being disturbed it made a very short flight and returned to the underside of the same leaf. Evidently the above-described position is assumed to allow for drying and inflation of the wings.

Mating.—A male was observed to fertilize a female approximately 3 minutes after the emergence of the latter, the entire operation taking 10 seconds. One male was observed to fertilize three females in rapid succession.

TABLE I.—*Longevity of adults and date of oviposition.*

Cage.	Adult emerged.	Number.		Oviposition.	Adults died.		Length of life.
		Male.	Female.		Male.	Female.	
	1917.						Days.
1	Apr. 2, a. m.	0	1	None		Apr. 5, a. m.	3
2	Apr. 5, a. m.	0	2	do		Apr. 8, a. m.	3
3	Apr. 6, a. m.	3	0	do	Apr. 6, p. m., 2		½
					Apr. 7, a. m., 1		1
4	Apr. 10, a. m.	2	2	Apr. 10	Apr. 10, p. m.		½
						Apr. 11, a. m.	1
5	do	2	2	None	Apr. 10, p. m.		½
						Apr. 12, a. m.	[1] 2
6	Apr. 11, a. m.	0	1	do		Apr. 13, p. m.	[1] 2½
7	Apr. 12, a. m.	0	2	do		do	1½
8	Apr. 13, a. m.	3	1	Apr. 13	Apr. 13, p. m., 2	Apr. 14, a. m.	2
						Apr. 14, a. m.	[1] 1
					Apr. 14, a. m.		1½
9	do	1	1	do	Apr. 13, p. m.		½
						Apr. 14, a. m.	1½
10	do	0	1	None		Apr. 17, a. m.	[1] 4
11	Apr. 17, a. m.	0	1	do		Apr. 20, a. m.	3
	1918.						
12	Jan. 31, a. m.	0	2	do		Feb. 1, a. m.	1
13	do	0	2	Jan. 31		Feb. 2, a. m.	2
14	do	0	1	do		Feb. 1, a. m.	1
15	do	1	2	do	Lost	Feb. 2, a. m.	2
16	Feb. 1, a. m.	0	2	Feb. 1		do	1
17	Feb. 11, a. m.	0	2	Feb. 11		Feb. 13, a. m.	2
18	Mar. 14, a. m.	1	0		Mar. 15, a. m.		1
19	July 10, a. m.	0	1	July 10		July 11, a. m.	1
20	July 17, a. m.	1	1		July 17, p. m.		½
						July 18, a. m.	1
21	July 18, a. m.	0	1			July 20, a. m.	2
22	July 19, a. m.	1	0		July 20, a. m.		1
23	Aug. 2, a. m.	2	0		Aug. 3, a. m.		1
24	Aug. 3, a. m.	0	1	Aug. 3		Aug. 3, a. m.	½
25	Aug. 5, a. m.	0	1	Aug. 5		Aug. 6, a. m.	1
26	Sept. 2, a. m.	1	0		Sept. 2, p. m.		½

[1] Female not fertilized and did not deposit eggs.

Longevity of adults.—In the life-history studies it was found that males usually live less than 12 hours, while the females live from 2 to 3 days, in captivity and when not mated. Mated females probably do not live over 24 hours. In the case of three males which were seen to emerge after 1 a. m., all were found dead at 5.45 a. m. These results are given in detail in Table I.

Activity.—The males are not often seen on the wing, as they die shortly after mating, which takes place during the early morning hours, almost directly after emergence. When on the wing, however, they are very active. The females, while generally rather sluggish, may show great activity at times, especially in the early morning and just prior to egg deposition. Dietz observed that on cool days when the temperature was 50° F. in the daytime, and cooler at night, the adult females were exceedingly active. Emergence records taken on many cages show that there are a somewhat larger number of females than males, the actual count being 464 females to 365 males.

Egg deposition.—The female when laying eggs keeps her legs at equal distances apart and the ovipositor held at right angles to the rest of the body, beginning probably at the third or fourth abdominal segment. If not disturbed she acts with great precision. On one occasion a female was carefully observed during two operations, laying 34 and 19 eggs respectively. The first oviposition period lasted exactly 3 minutes and 30 seconds, the second only 1 minute and 20 seconds. An interval of only 10 seconds elapsed between the operations. The tip of the long flexible ovipositor is thrust between the pubescent hairs of the young terminal growth and pressed down firmly on the surface. During deposition the eggs may be seen moving down the tube with great rapidity, accompanied by slight contractions of the ovipositor. Because of its darker color, the egg is plainly visible through the walls of the ovipositor. The number laid at one time, according to Table II on page 10, varies from 5 to 135, with an average of 32. Guyton (31) found that "the number deposited by each female is from 80 to 150." The eggs are usually placed in irregular masses, although they may be placed in strings or chains. During the whole operation the ovipositor is thrust around in a very nervous manner. At times when the female moves slightly about, the body is not straightened out but dragged along to the new place of deposition, in the original bent position. Although egg-laying may take place up to and later than 4.30 p. m., the maximum egg-laying occurs from the early morning hours up to midday. The midges prefer to lay eggs on the terminal growth of the plant on which they emerge, and particularly on the unfurling tip growth. This is true even in cases

where the terminal growth has been badly distorted previously as a result of their work. Females have been noted to return to such plants from which they have emerged and deposit eggs thereon. Even though they were repeatedly disturbed, they would return quickly and continue deposition. On many occasions it was found that when these young tips were separated and examined, the eggs would be present in greater numbers between the folds of the new tissue than on the neighboring exposed surfaces.

Incubation.—Observations, as given in Table II, show that the incubation period varies from 3 to 16 days. The time of incubation may be affected by the season of the year.

TABLE II.—*Length of egg period.*

Cage.	Host plant.	Deposited.	Hatched.	Length.	Number deposited.
		1917.		*Days.*	
1	October Frost	Apr. 2	Apr. 7	5	No records.
2	Snow Queen	Apr. 3	Apr. 8	5	Do.
3	Silver Wedding	Apr. 4	Apr. 9	5	Do.
4	Golden Glow	Apr. 5	Apr. 10	5	Do.
5	Harvard	Apr. 6	Apr. 11	5	Do.
6	Esanath	Apr. 7	Apr. 12	5	Do.
7	Snow Queen	Apr. 10	Apr. 15	5	Do.
8	Monrovia	Apr. 12	Apr. 17	5	Do.
9	Martha Saunders	Apr. 13	Apr. 18	5	Do.
10	Gold Chadwick	Apr. 16	Apr. 21	5	Do.
11	Esanath	Apr. 17	Apr. 22	5	Do.
12	Monrovia	Apr. 20	Apr. 25	5	Do.
		1918.			
13	Silver Wedding	Jan. 31 / Feb. 1	Feb. 9	8–9	Do.
14	do	do	Feb. 7	6	Do.
15	do	Feb. 2	do	5	25 eggs.
16	Dr. Enguehard	Feb. 11	Feb. 15–19	4–8	No records.
17	Pompom	Feb. 28	Mar. 6	6	Do.
18	Silver Wedding	Mar. 1	Mar. 6–10	5–9	Do.
19	Dr. Enguehard	Mar.	Mar. 9	5	Do.
20	Dr. Pool	Aug. 26	Sept. 6	11	34 eggs.
21	Mrs. R. N. McLuckie	Aug. 27	Aug. 30	3	19 eggs.
22	Margaret Bissett	Aug. 29	Sept. 4–14	6–16	5 eggs.
23	Silver Wedding	do	Sept. 6	8	20 eggs.
24	Menea	do	Sept. 6–14	8–16	24 eggs.
25	Silver Wedding	Sept. 5	Sept. 10–14	5–9	25 eggs.
26	Golden Wedding	Sept. 21	Sept. 24	3	135 eggs.

Development.—The development of the larva within the egg can be made out easily. In the newly laid egg the nucleus, which is reddish in color, is rather central, but shows a slight tendency to be located toward the anterior end. There are approximately 18 yolk bodies present which are arranged in a row of 9 on each side. The rows do not extend quite to the posterior end of the egg. As development proceeds the red pigment or nucleus moves to one side of the egg, which later is apparently the ventral surface. In the meantime the yolk bodies collect in a mass near the nucleus. At each end the small air spaces, which at first are relatively small, later become much increased in size. The segmentation then begins to appear, with a simultaneous contraction of the entire contents. A redistribution of

the yolk then takes place, an equal portion being present in each segment. At this stage the pigment takes up a posterior position. Finally the complete outline of the larva is visible through the shell. At this stage the darker head and mouth parts can be seen, and the previous yolk material appears as a chainlike formation which extends from the anterior to the posterior end throughout the entire inner or central portion of the body. Distinct segmentation is now clearly visible.

Hatching.—Borden observed the larva when hatching to break from the eggshell by a small cap at one end. Complete development of the larva and pupa takes place within the gall.

LARVAL AND PUPAL STAGES.

The larva or maggot upon hatching moves about on the surface among the plant hairs for a period of from 1 to 3 days, preparatory to boring into the tissue. It varies in color from a transparent white to pale orange when seen with the aid of a binocular just after boring beneath the epidermis. On February 2, 1918, H. F. Dietz observed larvæ, which hatched from eggs laid four days previously, boring into tissue. (10× eyepiece, 24 mm. objective, binocular.) The observations were as follows: One larva which was found half buried in the tissues of the stem was timed until it disappeared. It required 12 minutes for complete disappearance. During this period the larva moved back and forth with an irregular spiral movement, about 30 seconds being necessary for one complete movement back and forth. Several larvæ were then observed beginning to bury themselves, but the operation was interrupted and discontinued, the interruption being caused by another larva which was slowly crawling about in search of a suitable place to "dig in." One of these larvæ was observed crawling slowly about for approximately 3 minutes. The bright red pigment of the posterior third of the body is very characteristic at this particular stage.

As a result of the larva boring into the tissue, an irritation is produced which results in the production of swellings or galls on the plant containing the developing larvæ and pupæ.

No molts have been observed from the time of hatching to the time at which the larva is seen entering the tissue. The larva lies bathed in a fluid within the gall. The fully developed larva is of an orange color.

The female pupa is usually orange colored with the head, thorax, legs, and wing pads nearly black, while the male may be of a lighter or straw color. Formation of the pupa takes place about two weeks from the time the egg is hatched. It is white at first with only a slight brown tinge about the head, but later the head, thorax, wing-

pads, and legs are dark brown, and the abdomen orange. The cephalic horns are distinct in the nearly mature form of the pupa.

When mature the pupa works its way out of the gall. On emergence a split is made upon the dorsal line of the head and thorax of the pupal case through which the adult issues. (Pl. I, A, D.) During emergence the adult is very active and issues very rapidly.

From the time that the larva enters the tissue to the first sign of a swelling, or gall, observations on 18 life-history cages show that a period ranging from 4 to 14 days elapsed with an average of 7 days (see fourth column of Table III). The young gall may now be readily recognized by the characteristic white spots, or slight swellings.

It takes from 21 to 46 days, with an average of 28 days, from the time at which the larva first enters the tissue until the emergence of the adult. These observations were taken from the results obtained from 18 cages during the spring of 1917 and the spring and fall of 1918, as is shown in the following table. Britton (32) found it to require from 20 to 50 days to transform within the gall.

TABLE III.—*Time required from: (a) larva entering tissue until first sign of gall; (b) larva entering tissue until emergence of adult.*

Cage.	Larva entering tissue.	First sign of gall.	Time required (a).	Date of emergence.	Total length (b).
	1917.		*Days.*		*Days.*
1	Apr. 7–11			Apr. 29 to May 2	22
2	do			Apr. 30	[1] 21
3	do			May 1–2	23
4	do			Apr. 30 to May 2	22
	1918.				
5	Feb. 7	Feb. 13–16	7	Mar. 4	25
6	do	do	7	Mar. 4–7	26
7	Mar. 6–12	Mar. 15	6	Apr. 6–22	36
8	Mar. 6–10	do	7	Apr. 8–22	38
9	Mar. 12	Mar. 18	6	Apr. 27	[2] 46
10	do	Mar. 16	[1] 4	do	[2] 45
11	do	Mar. 18	6	Apr. 6	25
12	do	do	6		
13	Aug. 31	Sept. 9–19	[2] 14	Sept. 25	25
14	Sept. 2	Sept. 9	7	Oct. 2	30
15	Sept. 4–14	Sept. 17	8	Sept. 26 to Oct. 3	[1] 21
16	Sept. 4–11	Sept. 11	7	Sept. 27 to Oct. 2	22
17	Sept. 7–14	Sept. 14–19	6	Oct. 4	23
18	Sept. 24–25	Oct 2	8	Oct. 24 to Nov. 2	34

[1] Minimum time. [2] Maximum time.

From Table IV it is evident that the total life cycle requires from 27 to 52 days, with an average of 35 days. These data represent the results obtained from 17 life-history cages under Washington conditions. There is a constant overlapping of broods when the greatest numbers are present, namely in the spring and fall of each year. The æstivation period has been found to extend, in Maryland, Virginia, and the District of Columbia, from the early part of June to the latter part of August.

TABLE IV.—*Length of complete life cycle.*

Cage.	Eggs deposited.	Adult emerged.[1]	Length of life cycle.
	1917.		*Days.*
1	Apr. 2	Apr. 29 to May 2	27–30
2	....do	Apr. 30 to May 2	28–30
3	....do	May 1 to May 2	29–30
	1918.		
4	Feb. 1	Mar. 4	31
5	Feb. 2	Mar. 4 to Mar. 7	30–33
6	Mar. 1	Apr. 8 to Apr. 22	38–52
7	Mar. 5	Apr. 6	32
8	Mar. 6–9	Apr. 22 to Apr. 27	47–49
9	Aug. 3	Sept. 4 to Sept. 6	32–34
10	....do	Sept. 11 to Sept. 18	39–46
11	Aug. 6	Sept. 5	30
12	Aug. 27	Sept. 25 to Oct 4	29–38
13	Aug. 29	Sept. 26 to Oct 3	28–35
14	....do	Sept. 27 to Oct 2	29–34
15	....do	Oct 2	34
16	....do	Oct. 4	36
17	Sept. 21	Oct 24 to Nov 2	33–42

[1] Data given in Table I show that mated females deposit eggs on date of emergence.

In the spring of 1917, 1918, and 1919, three distinct generations were observed. The first generation started about the middle of February and the last adults of this generation emerged during the last few days of April. The second generation started about the middle of March and the last adults issued around April 30. The third generation started the latter part of April and emerged during the early part of June. In the fall of 1918 when the occurrence increased again a similar grouping of generations was evident, the first beginning about the latter part of August, and the last adults emerging during the first days of October. A second generation started about the middle and latter part of September, maturing the first days of November. The third generation was observed beginning about the middle of October and the last adults emerged about November 25.

NATURAL ENEMIES.

Felt (20), in speaking of the natural enemies of the midge, states that—

> It was very likely brought to America without the normal quota of parasites and for a time at least it may prove to be a somewhat difficult insect to control, though it would seem as if the native parasites of our large and varied gall midge fauna might in time prey most successfully upon this midge.

Essig (18) mentions:

> During the summer a large number of parasites were reared from infested plants and one species in particular did excellent work in the university greenhouse. The material was sent away for determination and a few observations made as follows:
>
> *Amblymerus* sp. This hymenopterous parasite has been described by Mr. A. A. Girault, through the kindness of Dr. L. O. Howard, and a description is to appear elsewhere. The adults are black with yellow markings on the legs. The females vary from 1 mm. to 1.2 mm. in length, and the males are somewhat smaller. The

larvæ live within the galls alongside the maggots of the gallfly, which they gradually consume. They remain within the galls until mature, when they emerge through small circular holes. This species is the most abundant during the summer months and all of the adults were reared during August, September, and October. In not a few cases as high as 80 per cent to 90 per cent of the maggots were destroyed.

Tetrastichus sp. The generic determination of this insect was made by Mr. Harry S. Smith, superintendent of the State insectary, Sacramento, Calif. It is also a small black parasite, somewhat larger than the former and easily distinguished from it by the four-jointed tarsi and other characters.

EXPERIMENTS IN CONTROL.

At the outset it must be borne in mind that it is very important that control measures should be closely related to the propagation of the stock, and moreover from the practical and economical point of view these steps should be undertaken at a period in the propagation when the plants can be severely cut back, allowing sufficient time to overcome any injury which may result from such treatment. Inasmuch as cuttings are propagated from the stock plants of the previous season, it is evident that the logical time to eradicate an infestation of long standing is immediately after the flowers have been removed. Naturally such precautions as would absolutely safeguard the grower against further spread and increase would have to be inaugurated.

An experiment conducted in one of the commercial greenhouses in the District of Columbia in which the plants had been heavily infested the previous season was carried out as follows: These heavily infested stock plants were heeled in and pruned back, and the entire portion above ground was thoroughly dusted with a mixture of equal parts of tobacco dust and air-slaked lime as often as the new growth appeared. As a result of such treatment the new growth was kept practically clean from further infestation and the plants at the same time showed a stimulated growth. The checks which were run simultaneously had all the new growth badly infested.

Occasionally it may happen that a grower's previous season's stock was clean and new material or varieties are being received in the form of cuttings or young plants from localities where the insect is known to exist. There is a possibility of introducing the midge on such stock even though no definite signs of the insect are visible. In the spring when cuttings and young plants are being exchanged, an infestation, especially in the egg or very young larval stage, will defy even the most careful and zealous inspectors. Interception made of plants harboring the eggs only can easily be overlooked by virtue of their concealed location in the still unfurled leaf bud.

A precautionary treatment should be given at the time when the plants or cuttings are taken or received and would prove of inestimable value in killing the eggs and immature stages.

The question of controlling an infestation already in the well-developed gall stage as well as the adult stage must also be con-

sidered. The control of the adult stage need not be taken up in experimental manner, in view of the known fact that such fragile flies can easily be controlled by light fumigation with hydrocyanic-acid gas or by burning tobacco papers, provided it is done at the correct time.

The preceding paragraphs clearly point out the advisability of determining the practical value of the several premises stated. Incidentally such factors must necessarily be solved independently of each other, but with the final view of either applying each separately when the case so warrants or consolidating such phases as would be most practical and consistent with commercial practices. The practical conclusions and recommendations that follow were deduced from results that are outlined and stated in the following pages.

EXPERIMENT 1.—CONTROL OF EGGS BY MEANS OF DIPPING INFESTED CUTTINGS.

Emphasis has been placed on the importance of beginning with clean cuttings in the spring. It, therefore, was found advisable to test out this point, and, if effective, such practices would be a safeguard to growers whose stock was badly infested as well as growers who had received outside material.

Three lots of six cuttings each were treated by J. L. Dietz as given in the following table. After treatment they were planted in sand. The tray, together with the plants, was then protected from further attacks by placing it under a close-mesh screen. The plants were treated September 26, and observations taken October 5 and 10 and November 1 are given in Table V.

TABLE V.—*Control of eggs by means of dipping infested cuttings.*

Experiment.	Treatment.	Observations and results.
1	40 per cent nicotine sulphate (1–500); laundry soap 1 ounce to 1 gallon; tips of cuttings dipped. Sept. 26, 1918.	Nov. 1: Eggs did not hatch; no new galls developed; 4 plants well rooted, 2 plants poorly rooted.
2	Same treatment as above, except that entire cuttings were dipped. Sept 26, 1918.	Nov. 1: Eggs did not hatch; no new galls developed, neither did original galls develop any further; 4 plants well rooted, 2 plants poorly rooted.
3	Check; no treatment	Nov. 1: Eggs hatched; 1 plant had 3 well-developed galls present; 3 plants rotted off; 3 plants were well rooted.

DISCUSSION OF RESULTS.

Comparing the results of both treated lots with those of the check, the results are fairly conclusive. On the treated plants the eggs in each case did not hatch, neither did the young galls originally present make further progress, whereas, in the case of the check, while only one plant showed definite results, it is clear that the galls developed.

The effect of such treatment on the plants is somewhat inconclusive due to the rotting off of three plants in the check. In the case of the treated plants, four survived in each lot.

EXPERIMENT 2.—CONTROL OF EGGS BY MEANS OF DIPPING ENTIRE PLANT.

The object of this experiment was practically synonymous with that of experiment 1 except that entire plants were used instead of cuttings as was the case in the previous test.

Twelve plants on which newly laid eggs were present were divided into three lots, (a), (b), and (c), of four plants each. They were then treated as follows:

(a) Four plants dipped in 40 per cent nicotine sulphate (1–500) plus laundry soap 1 ounce to 1 gallon of solution.
(b) Four plants dipped in 40 per cent nicotine sulphate (1–800) plus laundry soap 1 ounce to 1 gallon of solution.
(c) Four plants as check; no treatment.

In each case the plants were constantly protected by covering them with an ordinary lantern globe, the free end of which was screened with a double layer of cheesecloth. The first dipping was done on March 29, while subsequent dippings were done on March 31 and April 1, 3, and 8. The plan was to treat them at least every 2 or 3 days for a week or 10 days. Observations were taken frequently on the effect of the treatment both on the plants and on the eggs. These observations were continued until the close of the experiment, April 30, at which time the plants were uncovered and placed in the open greenhouse.

Results.—(*a*) Effect on plants: Slight burning was encountered with the 1–500 strength solution, but with the 1–800 solution no such trouble was evident. The check plants showed some sooty fungus which was probably due to the presence of honeydew secreted by aphids. (*b*) Effect on eggs: During the first few days the eggs showed normal development within the shell on the treated plants, but larvæ failed to hatch from them, and no galls developed. On the check plants all of the eggs hatched successfully and many galls developed to maturity.

Conclusions.—The expectations were fully confirmed by the results obtained, as was the case in experiment 1. The checks developed healthy and normal galls while in the treated plants further development was promptly arrested. From the economical point of view it is safe to say that nicotine sulphate (1–800) plus the soap will control the egg stage effectively if properly applied.

TREATMENT OF BOTH CLEAN AND INFESTED CUTTINGS.

The importance of having all new stock free and clean from the immature stages of the midge and of having the control at all times closely related to the propagation of stock has already been referred to. The above points were tested by the following experiment.

This test consisted of three parts. Lots 1 and 2 were clean cuttings, while lot 3 consisted of infested cuttings. Each lot was sub-

divided into three divisions or rows, namely, (a), (b), and (c). The last, (c), in each case served as a check on (a) and (b), which were the treated rows. The first treatment consisted of dipping the cuttings directly after they were taken, and the subsequent treatments consisted in spraying daily for a period of 7 days thereafter with a solution of the same strength.

Lot 1 consisting of clean cuttings to be used as a check was kept in a separate and uninfested unit for the purpose of determining the effect of such treatment on the cuttings. Lot 2 consisting of clean cuttings and lot 3 of infested cuttings were both tightly screened and placed in a propagating frame in an infested unit. In this manner it was hoped to determine the effectiveness of such treatment when both clean and infested cuttings had to be grown together.

LOT 1.

Six clean cuttings in each row.

Row (a). Nicotine sulphate (1–800) plus fish-oil soap 1 ounce to 1 gallon of solution.

Row (b). Volatile nicotine sulphate (1–800) plus fish-oil soap 1 ounce to 1 gallon of solution.

Row (c). Checks; not treated.

Results.—During the period of treatment it appeared as though all the plants were affected slightly. Row (a): The lower leaves of all the cuttings turned yellow, but 10 days after treatment was discontinued all but one cutting were in fine condition. Row (b): Even though no direct signs of burning were evident, the plants appeared sickly during the second and third treatments. Ten days after the discontinuance of the treatments the cuttings were in better condition than either (a) or (c). The check row (c) was slightly affected due to its proximity to the treated rows. Ten days after treatment was stopped only two plants were in good condition and one was poor.

The conclusion to be drawn from this test is that the method of treatment under (b) was probably the better of the two.

LOT 2.

Seven clean cuttings in each row. Placed in infested unit after first treatment.

Row (a). Nicotine sulphate 40 per cent (1–1,000) plus fish-oil soap 1 ounce to 1 gallon of solution.

Row (b). Volatile nicotine sulphate 40 per cent (1–1,000) plus fish-oil soap 1 ounce to 1 gallon of solution.

Row (c). Checks; no treatment.

Results.—Although this dosage was weaker than that used in lot 1, it affected the cuttings much more. After the second and third treatments the plants all looked wilted. Ten days after the last

application all the cuttings but one in row (a) were dead. In row (b) all looked very poorly. In (c), the check row, one cutting was dead while all the remainder looked fairly healthy.

Conclusions.—It appears that the variety may have played an important part in this case. In this lot, as was so evident in the previous treatment, (a) causes injury, while (b) gives a double benefit—first, it does not cause injury; and second, it protects the plant. The midges spread to the check row (c), and two galls had adults emerge from them.

LOT 3.

Three rows of seven infested cuttings each.

Row (a). Nicotine sulphate 40 per cent (1–1,000) plus fish-oil soap 1 ounce to 1 gallon of solution.

Row (b). Volatile nicotine sulphate 40 per cent (1–1,000) plus fish-oil soap 1 ounce to 1 gallon of solution.

Row (c). Check; not treated.

Results.—This variety stood up much better than did that in lot 2.

Row (a). Slight burning evident. In fair condition 10 days after treatment.

Row (b). Only two poor plants; no burning. All recovered 10 days after treatment.

Row (c). All plants in good condition, slightly better than row (b). No galls developed.

Either treatment (a) or (b) might be used successfully.

FINAL CONCLUSIONS.

Comparing the three lots with one another the following conclusions may be drawn: The practices described injure the cuttings only slightly and afford reasonable protection from the midges.

EXPERIMENTS ON CONTROL OF GALL STAGE.

The final consideration concerns the control of the gall stage, which is the hardest to combat. Owing to the habit of the larvæ of burrowing into the plant tissues, the chief difficulty is that most spraying mixtures when applied to foliage fail to exert their toxic properties against the insects contained therein. This may be accounted for by the resistance of the leaf structures to penetration by insecticides.

EXPERIMENT 1.

A preliminary experiment, in which was used 1 part 40 per cent nicotine sulphate to 250, 500, and 1,000 parts water, respectively, to which fish-oil soap or laundry soap at rate of 1 ounce to each gallon of solution was added, showed conclusively that one application was entirely ineffective in controlling the gall stage. The data which were taken at various intervals showed that the adults emerged

successfully and continually. Hence, it was decided to test out the efficiency of several applications when made two and three days apart. The test is given in the next paragraph.

EXPERIMENT 2.

In the treated lots five plants were used for (a), (b), (e), and (f), and six plants for (c) and (d) for each test. The plants used had been growing in pots. Only two plants were used in both checks. The dipping was done as indicated every two or three days. Observations were taken daily.

TABLE VI.—*Results of experiment 2.*

Started.	Closed.	Treatment.	Total emerged.	Total killed.	Percentage of efficiency.	Remarks and conclusions.
1919.						
(a) May 1...	May 10..	Nicotine sulphate (1-500), fish-oil soap 1 ounce to 1 gallon.	217	123	56.6	Greatest efficiency within 24 hours of treatment.
(b) May 1...	May 10..	Nicotine sulphate (1-800), fish-oil soap 1 ounce to 1 gallon.	152	86	56.5	Same as above.
(c) May 19..	May 23..	Nicotine sulphate (1-1,000), fish-oil soap 1 ounce to 1 gallon.	45	30	66.6	Lower leaves turned yellow and died on most plants.
(d) May 19..	May 23..	Volatile nicotine sulphate (1-1,000), fish-oil soap 1 ounce to 1 gallon.	72	35	48.6	Slight blackening of tips on larger leaves.
(e) May 1...	May 10..	Linseed-oil emulsion plus nicotine sulphate(1-800).	80	2	2.5	Not efficient.
(f) May 7....	May 9...	Fish-oil soap 1 ounce to 1 gallon.	Many.	0	0	All emerged successfully; not efficient.
(g) May 1...	May 10..	Check.....	Many.	0	0	All emerged successfully.
(h) May 19..	May 23..	Check.....	Many.	0	0	Same as above.

Discussion of results.—The data represented in Table VI are self-explanatory as to the relative value of the various strengths and combinations of insecticides. The mathematical representation of the first two lots does not clearly define the actual state of affairs. It was repeatedly observed that on the day following treatment the number of adults killed was usually larger than on the second or third day. In other words, the effectiveness of such practices depends entirely on the interval which elapses between applications, and the conclusion to be drawn is that nightly or daily applications are absolutely necessary to get the maximum killing. The insecticide proved to be effective in killing the adult in the act of emergence, but did not sufficiently penetrate the tissues of the leaves to kill the immature stages within the galls. The column "Total killed" is understood to mean the killing of the adult in the process of emergence (Pl. II, B). It is also important that the treatment should be applied when the adults are almost ready to emerge from the galls.

EXPERIMENT 3.

In the foregoing experiment it will be observed that good results were obtained with the nicotine sulphate diluted to 1–800. Another point upon which it seemed desirable to have more definite information was the effectiveness of applications made daily compared with those made two days apart. In the following experiment two lots were treated, while the third lot served as a check. The empty galls were punctured and all old pupal skins were removed from the plants in question. Eighteen plants were employed in each of the two treated lots, which were sprayed a total of five times. Five plants served as a check.

TABLE VII.—*Results on first and second days after treatment.*

Lot.	Treatment.	Results first day after treatment.				Results second day after treatment.			
		Males.	Females.	Total killed.	Pupal skins.	Males.	Females.	Total killed.	Pupal skins.
1	Nicotine sulpnate 40 per cent (1–800) and soap	38	43	81	15	1	1	2	16
2	Volatile nicotine sulphate 40 per cent (1–800) and soap	18	18	36	22	1	2	3	23
3	Checks	0	2	2	74				

Conclusions.—The results are very conclusive and show distinctly that the best results are obtained by daily application. There is a remarkable decrease in the numbers caught on the second day following treatment. Nicotine sulphate, therefore, used at the rate of 1–800 plus soap (1 ounce to 1 gallon) will control the adult on emergence, and hence is very well adapted to such cases where fumigation can not be followed consistently.

EXPERIMENTAL WORK IN COMMERCIAL CHRYSANTHEMUM GREENHOUSES.

Experimental work in a commercial greenhouse in Baltimore during the summer of 1918 seems to indicate that the chrysanthemum midge can be held well under control by spraying the infested plants with 40 per cent nicotine sulphate applied at the rate of 1 part of nicotine sulphate to 500 parts of water, with the addition of one-half ounce of soap to each gallon of solution. No appreciable injury followed the application, although the plants were sprayed every other day for a period of six weeks. The application of this treatment by the grower resulted in his producing especially fine chrysanthemums. It would appear that a double benefit was realized by such practices. In the first place it controlled the insect, and, secondly, a distinct stimulation of growth followed. This seems to confirm the work of Gossard (30) and Guyton (31), who claim that 40 per cent nicotine sulphate diluted with 500 parts of water and

fish-oil soap will kill the adult almost immediately after emergence, if the spray is applied not more than three or four days previously.

A separate sash house was erected closely adjoining the greenhouse in which the spraying was done. Here 100 plants were fumigated nightly for approximately eight weeks, tobacco paper at the rate of 1 sheet to every 650 cubic feet of space being used. While some burning resulted, the midge was held in check. From these two experiments it is evident that either practice would be efficient.

A large commercial grower in Indiana reports that following instructions of this bureau he entirely eliminated the midge from his houses by fumigating with tobacco papers every night from December 20, 1917, to March 20, 1918.

Experiments conducted in several greenhouses in the District of Columbia in 1919 have indicated that consistent nightly fumigation is very effective in keeping down this insect. In several places where this was not advisable an effective spray was applied, consisting of nicotine sulphate (1–800) plus soap (one-half ounce to 1 ounce to each gallon of solution).

SUMMARY OF CONTROL AND RECOMMENDATIONS.

From the life history, as well as from the experimental data thus far submitted, it is clear that certain points must be kept in mind if the best practical results are to be secured. First, several generations are always present in greenhouses during the spring and fall occurrences; second, the adults emerge and mate during the very early morning hours, and egg laying quickly follows; third, preliminary control experiments show that the egg stage may be controlled by means of spraying or dipping the cuttings or plants; fourth, it has been demonstrated that the adult can be killed easily at the time of emergence by consistent spraying; fifth, fumigation experiments in a commercial house proved that the adult is easily killed by fumigation either with nicotine papers or hydrocyanic-acid gas; sixth, experiments applicable to general propagation practices show conclusively that such measures offer a reasonable safeguard and protection against doubtful stock and infested material without injury to the plants.

By adherence to a definite control program, involving any of the above cited measures, either singly or in combination, the insect can be readily controlled.

In case of a very light infestation daily picking of gall-infested leaves will hold the pest in check. Should this practice prove ineffective, nightly fumigation for a period of two or three weeks may be resorted to.

When a severe infestation is encountered the most heavily infested plants should be taken out immediately and burned.

This should then be followed by either fumigation or spraying as outlined below.

Fumigate every night, with either nicotine papers or hydrocyanic-acid gas, for a period of at least six weeks. This will kill all the adults that emerge during such a period and at the same time will prevent the further laying of eggs for future generations. The dosage need not be very heavy in either case. When nicotine papers are used one sheet to every 1,000 cubic feet of space will suffice. If hydrocyanic-acid gas [1] is employed, one-eighth to one-fourth ounce per 1,000 cubic feet will kill all of the adults. The use of hydrocyanic-acid gas is not recommended unless in the hands of a competent fumigator, owing to its deadly poisonous effects. Too much emphasis can not be laid on the fact that the fumigation must be set off after 12 o'clock, midnight, to be effective. It is preferable to start the generation between the hours of 12.30 a. m. and 2 a. m. Any fumigation done before midnight would be useless for it has been pointed out that the adult does not emerge until after midnight. On the other hand, if it is started later than 2 a. m. many adults will have emerged and laid their eggs.

In case fumigation is not advisable, especially where chrysanthemum plants are isolated or when other varieties of plants are present in the houses, spraying is recommended. This must be done consistently for a period of four to six weeks, a 40 per cent solution of nicotine sulphate extract diluted (1–800) being used, and soap added at the rate of one-half to 1 ounce per gallon of solution. The application should be made late in the afternoon in order that the best results may be obtained. In this manner practically all adults can be killed at the time of emergence and any eggs present will be destroyed.

PREVENTIVE MEASURES.

It has been proved that the means of disseminating this insect has been the shipment of infested chrysanthemums, both plants and cuttings. Interceptions made by the various State inspection officials, as well as by inspectors of the Federal Horticultural Board, definitely confirm this fact. It is therefore imperative that only clean plants and cuttings be brought into commercial houses where chrysanthemums are growing or to be grown. Growers should carefully examine all chrysanthemums received and see that all material intended for shipment or distribution is free from this pest. Any questionable material should at once be submitted to the State

[1] For further information on the use of hydrocyanic-acid as in fumigating greenhouses, see Farmers' Bulletin [illegible]

experiment station or to the Bureau of Entomology, United States Department of Agriculture.

The California Experiment Station (18) recommends the practice of growing the bulk of the chrysanthemum crop under cloth as a satisfactory means of preventing the attack of the gall-fly.

As a further preventive measure, it is recommended that cuttings be dipped in the following solution at the time they are taken:

Nicotine sulphate, 40 per cent	part..	1
Water	parts..	800
Laundry soap	ounce per gallon..	½–1

Another satisfactory method of securing chrysanthemum cuttings free from the midge when the previous season's stock has been infested is to plant the stocks in benches or cold frames directly after the season's crop has been removed. This should then be followed by thorough treatment with a mixture consisting of equal parts of dry or air-slaked lime and tobacco dust. It is advisable to keep all new growth covered with the mixture until further operations in the spring.

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